JORDAN POND RESTORATION STUDY
PHASE 2 – STORMWATER MANAGEMENT PLAN
SHREWSBURY, MASSACHUSETTS

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1.00 INTRODUCTION

1.01 AUTHORIZATION

The Board of Health of the Town of Shrewsbury (the Town) contracted GZA GeoEnvironmental, Inc. of Norwood, Massachusetts (GZA) to conduct a two-phase feasibility study for the restoration of Jordan Pond. Funding for this study was provided through a grant by the Commonwealth of Massachusetts through the Department of Environmental Management's (DEM) Lakes and Ponds Program. Authorization for GZA to proceed was granted by the Town on September 26, 2002. The Phase 1 Report was presented to the Town on February 25, 2003, and consisted of a diagnostic/ feasibility study of the condition of the Pond and recommended potential remedial actions. Based on the contents of the Phase 1 Report, the Town and the Jordan Pond Watershed Committee met on March 19, 2003 to discuss the scope of Phase 2 of the project. On March 24, 2003, the Town notified GZA that a study of options for in-line stormwater treatment was to be the focus of Phase 2 of the project. GZA submitted its proposed scope to the Town in a letter dated April 1, 2003. This scope was approved by the Board of Health Director in a letter dated April 9, 2003.

1.02 PURPOSE OF PHASE 2 STUDY

The purpose of this study is to examine in greater detail the option of utilizing in-line stormwater treatment systems to improve the quality of stormwater entering Jordan Pond from the contributing watershed. This study identifies and describes types of in-line stormwater treatment systems, discusses their performance characteristics, identifies and prioritizes potential locations for such systems, computes preliminary sizing needs, provides generic details and specifications, provides operations and maintenance guidelines, and presents preliminary cost estimates.

This Phase 2 report may be utilized as a planning document by the Town and Watershed Association for prioritizing, scheduling, and budgeting of the future installation of in-line stormwater treatment devices. The report should greatly expedite final design of the systems once the Town has completed its comprehensive survey and inventory of its storm sewer system. The Phase 2 report may also be useful in applying for grant money (such as 319b grants) which funds both final design and implementation of Best Management Practices (BMPs). The measures recommended in this report may also assist the Town in meeting the goals of the NPDES Phase II program, which now applies to small municipalities such as Shrewsbury.

While implementing stormwater treatment systems and other watershed controls is unlikely to lead to any immediate improvement of the aquatic vegetation problem at Jordan Pond, such measures are important to overall water quality, both in the Pond and further downstream. We believe that in-line stormwater treatment devices are an appropriate, relatively low-cost solution which, while not directly addressing the root causes of degradation in the Pond, may satisfactorily reduce future sedimentation loading to the pond. Combined with limited chemical treatments, these solutions may offer an alternative to large-scale improvement projects such as dredging or reverse layering, which are currently cost-prohibitive. In all cases, the cooperation and support of the Jordan Pond Watershed Association, the greater community, and the Town will be necessary to affect positive change in the Pond.

1.03 SCOPE

To achieve the purposes of the project and in response to the directives of the Town, Phase 2 of the Jordan Pond Restoration Study has addressed the following items:

1) Identify and discuss in-line stormwater treatment concepts and options: GZA has provided a summary of the concepts behind in-line stormwater treatment and discuss how such systems serve to improve water quality. GZA will also provide a list and brief description of several of the proprietary package systems available.

2) Identify and prioritize potential locations for in-line stormwater quality treatment devices: GZA has selected approximate locations where in-line stormwater quality treatment devices might be placed to assist with improving the quality of runoff entering Jordan Pond. Based on sub-basin land use and other factors, GZA has prioritized the proposed locations based on our judgment regarding potential overall water quality improvements. GZA contacted the Shrewsbury Engineering Department regarding "as-built" drawings of the existing storm sewer system.

3) Size in-line stormwater quality treatment devices: At each of the locations identified for potential installation, GZA has performed engineering calculations needed and made preliminary sizing recommendations for the in-line stormwater quality treatment devices.

4) Provide Generic Details and Specifications: GZA has provided the Town with generic detail drawings and specifications for in-line stormwater treatment devices. These details and drawings may be used when final designs and installation contracts are developed.

5) Provide Operation and Maintenance Guidelines: GZA has developed and provided the Town with operation and maintenance guidelines which will assist in the period cleaning and inspection of the in-line stormwater treatment devices. The O&M guidance identifies major equipment required and will recommend cleaning and inspection frequencies.

6) Preliminary Cost Estimates: Based on the number and size of devices recommended, GZA has developed preliminary cost estimates for the purchase and installation of the devices. We have formulated our cost estimate with reference to our prioritization schedule so that the Town may assess the cost of installing the devices in multiple phases.

This report is subject to the limitations set forth in **Appendix A**. A complete list of references used in the preparation of this report is included as **Appendix B**.

1.04 ACKNOWLEDGEMENTS

The project team for the Jordan Pond Restoration Study was comprised of individuals from a number of disciplines and organizations. GZA would specifically like to acknowledge the contributions of Nancy Allen and Bob Moore from the Shrewsbury Board of Health; Bruce Card from the Board of Selectmen; Brad Stone and Dan McCullen from the Engineering Department; and State Representative Karyn Polito. GZA would also like to thank the members of the Jordan Pond Watershed Association for all of their help.

2.00 PHASE 1 DIAGNOSTIC / FEASIBILITY STUDY SUMMARY

2.01 STORMWATER-RELATED WATER QUALITY CONCERNS

The diagnostic portion of Phase 1 of this study found a variety of problems potentially associated with stormwater to be present in Jordan Pond. The main issues associated with stormwater runnoff may be summarized as follows:

1) Sediment: The depth of Jordan Pond has decreased.
2) Nutrients: High nutrient concentrations. Likely primary source was watershed loading.
3) Bacteria: Animal origin. Concentrations not explained by direct waterfowl input. Likely due to material in stormwater runoff. Recommend no future swimming.

2.02 RECOMMENDED WATERSHED OPTIONS

The eutrophication of lakes and ponds is a naturally occurring process which typically takes places over thousands of years. Anthropogenic impacts have greatly accelerated this process in many area water bodies, and Jordan Pond is no exception. The best way to reduce negative impacts on urban water bodies is by working to curtail the introduction of new nutrients and pollutants from the watershed. Thus, watershed controls are paramount to any successful management plan and pond restoration program, including the Jordan Pond Management Plan. Many watershed management techniques can add environmental benefits beyond those applicable to pond restoration, many are common sense, and others are simply good housekeeping practices.

GZA recommends that the Town of Shrewsbury, in conjunction with the Jordan Pond Watershed Association, work with the residents of the Jordan Pond watershed to reduce the nutrient, contaminant, and solids loading to Jordan Pond. The recommended watershed controls include:

1. Expand existing public education, awareness, and outreach programs.
2. Develop additional such programs as necessary, including informational brochures and signage around the Pond. Educational efforts should focus especially on turf management (i.e. fertilizer use), pet waste disposal, garbage disposal use, and hazardous materials disposal.
3. Modify street sweeping and catch basin cleaning programs to operate on a more frequent basis. Streets within the Jordan Pond watershed should be given high priority for sweeping and cleaning in the spring so that much of the sand from winter applications can be removed before spring storms wash it into the Pond.
4. Enforce the ban on motorized vehicles on the trails adjacent to the Pond.
5. Landscape the beach area to minimize erosion (see Section 10.20 in the Phase 1 report).
6. Hold workshops on turf management and consider the creation of a rebate system for the purchase of low phosphorous or phosphorus-free fertilizers. The Massachusetts Executive Office of Environmental Affairs has recently published a guidance document to assist homeowners and others with choosing and implementing environmentally-friendly lawn care practices. This document is entitled "*More Than Just a Yard: Ecological Landscaping Tools for Massachusetts Homeowners*" and is available on the internet at http://www.state.ma.us/envir/mwrc/pdf/More_Than_Just_Yard.pdf
7. Stencil catch basins in the watershed to note that they drain to the Pond.
8. Install "pooper-scooper" signage and enforce pet waste disposal regulations.
9. **Install in-line stormwater treatment devices at key locations in the storm sewer system which conveys runoff into the Pond.**

3.00 WATERSHED CHARACTERISTICS AND SUB-BASIN DELINEATION

3.01 GENERAL DESCRIPTION AND LOCATION

Jordan Pond is a small natural pond located entirely within the Town of Shrewsbury, Massachusetts. The Pond appears to be a "kettle pond," which is a type of pond formed by a void left when sediment was deposited around a melting glacier fragment at the end of the last ice age. Jordan Pond is fed by stormwater drainage, surface water flow, and groundwater flow. Outflows from the Pond are conveyed into nearby Lake Quinsigamond. No named watercourses currently drain into Jordan Pond. A historic map dated 1887 shows a stream flowing into Jordan Pond from the north, whereas another historic map dated 1939 no longer shows this stream. The Pond is shown on the Marlborough, Mass. 7.5 x 15 minute USGS topographic quadrangle maps. The Pond is in Worcester County, Massachusetts, at approximately Latitude 42.269°N and Longitude 71.747°W. **Figure 3-1** is a locus map which shows the general location of the Pond and its urban watershed.

3.02 OVERALL WATERSHED DESCRIPTION

Jordan Pond receives flow emanating from the north via two 30-inch stormwater drainage pipes in addition to small twin PVC pipes directly draining Ridgeland Street. Groundwater flow and surface runoff from the east, south, and west also add inflow to the Pond. Outflow from Jordan Pond is infrequently conveyed as surface flow in a shallow, natural outlet channel to Lake Quinsigamond. Groundwater flow out of the Pond is also likely in the direction of Lake Quinsigamond. The watershed topography includes numerous small hills of glacial origin. The total watershed area is 195 acres; other key watershed characteristics are listed in the Phase 1 report.

The watershed which supplies Jordan Pond with runoff consists largely of urban areas which support industrial, commercial, residential land and land uses, as well as a sizable fraction of wooded land. Figure 3-3 in the Phase 1 report shows the land uses in the watershed area. Based on the land use map, topographic data, and other information the runoff characteristics of the overall watershed were calculated. The calculations are shown in Appendix H in the Phase 1 report and key results are listed in Table 3-1 in the Phase 1 report. The watershed land use is approximately 60 percent residential, 30 percent forested, and 10 percent commercial, and includes a portion of State Route 9, a major thoroughfare.

3.03 SUB-BASIN DELINEATION FOR STORMWATER TREATMENT PLANNING

For the purpose of this planning study, GZA has divided the Jordan Pond watershed into a number of sub-basins of interest as described in **Table 3-1** below. These sub-basins represent areas which are drained by discrete portions of the stormwater drainage system. Best available information on the stormwater system was provided by the Town of Shrewsbury Engineering Department. These sub-basin areas were assessed for potential sources of runoff contaminates to estimate the relative priority of stormwater treatment for each sub-basin. For sub-basins which are judged to be potential areas where in-line stormwater treatment would substantially improve water quality, treatment devises have been sized based on sub-basin characteristics and located based on the alignment of existing stormwater conduits. An aerial orthophoto showing the sub-basin delineations and designations within the Jordan Pond watershed is presented as **Figure 3-2**. A plan provided by the Town showing the locations of known storm sewers and catch basins is attached as **Appendix C**.

Note that not all areas of the Jordan Pond watershed have been separated into sub-basins. Open space and wooded areas which are not serviced by municipal storm sewers have not been sub-divided. Treatment of runoff from these areas via in-line devices is not possible and in general is of much lesser priority. Areas which drain directly into large-diameter, primary storm sewers were not sub-divided since the installation of in-line treatment devices on such large trunk lines is typically not recommended. Areas where there was insufficient data regarding existing storm sewers were likewise not sub-divided. The majority of such areas are at the furthest northern part of the overall watershed and generally deemed of lesser importance. Discussion regarding alternate stormwater management practices for the areas which were not sub-divided is contained in Section 7.00.

Sub-basin Designation:	**A**	**B**
General Location:	Brandywine Apartments	Pinedale Road / Villa Road / Wingate Street
Area:	9.8 acres	7.3 acres
Generalized Land Uses:	Multi-family housing	High-density residential
Assumed Major Stormwater Pollutants:	Nutrients, Pathogens, Sediment, Metals, Hydrocarbons, Salt, Organics	Nutrients, Pathogens, Sediment, Organics

Sub-basin Designation:	**C**	**D**
General Location:	Route 9 commercial development (eastbound)	Route 9 commercial development (westbound)
Area:	3.3 acres	1.6 acres
Generalized Land Uses:	Commercial	Commercial
Assumed Major Stormwater Pollutants:	Sediment, Metals, Hydrocarbons, Salt	Sediment, Metals, Hydrocarbons, Salt

Sub-basin Designation:	**E**	**F**
General Location:	Route 9, east of Svenson Road	Sterling Street
Area:	1.5 acres	4.6 acres
Generalized Land Uses:	Road	High-density residential
Assumed Major Stormwater Pollutants:	Sediment, Metals, Hydrocarbons, Salt	Nutrients, Pathogens, Sediment, Organics

TABLE 3-1. Jordan Pond Sub-Basins of Interest Descriptions

4.00 WATERSHED HYDROLOGY

4.01 CLIMATE

The climate in the Jordan Pond area is typical of central Massachusetts. On average, Jordan Pond receives approximately 47.75 inches of precipitation per year. Refer to the Phase 1 report for further discussion.

4.02 JORDAN POND WATER BUDGET

GZA performed simple hydrologic and hydraulic analyses of Jordan Pond to evaluate the relative impact of various Pond inflows and outflows on water quality in the Pond.

Estimated inflows to Jordan Pond include: baseflow (a.k.a. groundwater) (51%), runoff (direct and via storm sewers - 33%), and direct precipitation (16%). Outflows from the Pond include: streamflow (consisting of baseflow and surface water flow) and direct lake evaporation. There are no direct pumped discharges to or other man-made withdrawals from the Pond, and the Pond is not used as a public water supply. Refer to the Phase 1 report for further discussion of the water budget. Flow through the stormwater system comprises a majority of the runoff which flows into Jordan Pond.

4.03 STORMWATER FLOWS

Typical sub-basins of interest in the Jordan Pond watershed (i.e. those where in-line stormwater treatment systems might be installed) have been delineated with areas that range from approximately 3 to 9 acres. In general the longest dimension of the sub-basins do not exceed approximately 800 feet. The sub-basin areas are typically relatively flat areas which are drained via street gutters and underground stormwater pipes. Most of the sub-basins of interest are commercial or apartment housing which includes a high percentage of impervious area (roofs, parking lots, and streets) or single-family residential.

Based on these generalized characteristics, typical unitized stormwater flow rates may be developed and then applied to the various sub-basins of interest. Note that these are approximate values for use in planning purposes only.

Typical Runoff Velocity:	2 fps
Max. Drainage Path Length:	~800 ft.
Max. T_c:	~7 min.
Runoff Coeff. (C)	0.8 (commercial / apartments)
	0.5 (residential)

Modified Rational Method: $Q = Ca\ C\ i\ A$
(as per Mass. Highway Design Manual)

Generalized unitized peak runoff rates for a number of storms of interest, as calculated using the Modified Rational Method are presented in **Table 4-1**.

Storm Frequency	Rainfall Intensity (inches)	Commercial / Apts. Peak Runoff / Acre (cubic feet per sec.)	Residential Peak Runoff / Acre (cfs/acre)
	0.5	0.4	0.3
	1.0	0.8	0.5
2 years	4.0	3.2	2.0
10 years	5.2	4.2	2.6
25 years (Ca = 1.1)	6.0	5.3	3.3
50 years (Ca = 1.2)	6.8	6.5	4.1
100 years (Ca = 1.25)	7.4	7.4	4.6

Table 4-1. Generalized Unitized Stormwater Runoff Rates

These unitized rates are then applied to the six sub-basins of interest in **Table 4-2** to estimate peak flows through the storm sewers and therefore any proposed in-line treatment device. Typically, drainage system design utilizes storm events with return periods of between 10 and 25 years.

		Storm Event						
		0.5 in.	1.0 in.	2-yr	10-yr	25-yr	50-yr	100-yr.
Sub-Basin	Area (acres)	Approx. Peak Discharge from Sub-Basin in Cubic Ft. per Sec. (cfs)						
A	9.8	3.9	7.8	31.4	41	52	64	73
B	7.3	2.2	3.7	14.6	19	24	30	34
C	3.3	1.3	2.6	10.6	14	18	22	24
D	1.6	0.6	1.3	5.1	7	9	10	12
E	1.5	0.6	1.2	4.8	6	8	10	11
F	4.6	1.4	2.3	9.2	12	15	19	21

Table 4-2. Generalized Stormwater Runoff Rates for Sub-Basins of Interest

5.00 WATERSHED STORMWATER MANAGEMENT

5.01 STORMWATER QUALITY

Since flow through the stormwater drainage system represents the majority of the surface water entering Jordan Pond, stormwater quality has a major impact on the water quality within the Pond. The limited stormwater, pond water, and pond sediment data collected by GZA in Phase 1 of the study indicates the following stormwater pollutants of concern, and their likely sources within the Jordan Pond watershed, as summarized in **Table 5-1**.

Stormwater Pollutant	Potential Source(s)
Nutrients (Nitrogen and Phosphorus)	Fertilizers, Pet waste, Waterfowl
Solids (i.e. Sediment)	Road sanding, Urban & residential runoff, Construction sites
Pathogens (Bacteria and Viruses)	Pet waste, Waterfowl
Metals (especially Lead and Arsenic)	Roadway runoff
Hydrocarbons (e.g.: oil & grease, TPH, PAHs)	Roadway runoff
Salt	Road salting
Detergents & other household wastes	Urban & residential runoff

Table 5-1. Stormwater pollutants of concern in the Jordan Pond watershed and their likely sources.

As discussed in the Phase 1 report, there are multiple source controls and transport mitigation measures which are effective at mitigating both point source and non-point source pollution. These measures include:

- Source controls
    - Zoning and land use regulations
    - Public awareness/ education
    - Catch basin stencils
- Transport mitigation
    - Vegetated shoreline buffers
    - Detention ponds & created wetlands
    - Street sweeping/ catch basin cleaning
    - In-line stormwater treatment.

5.02 STORMWATER SAMPLING DATA

As part of the Phase 1 study, GZA sampled stormwater emanating from the two outfall pipes at Jordan Pond during a wet weather event; refer to our Phase 1 report for further detail.

The discharge from the northern outfall pipe reportedly appears "soapy" from time to time. The Town of Shrewsbury Board of Health has tested for the presence of MBAS in the past, with mixed success. MBAS, or Methylene Blue Active Substances, is a measure of anionic surfactants that are primarily found in household and industrial laundering and cleaning products. After being informed by a local resident of "suds" in the water on March 19, 2003, the Board of Health tested the stormwater effluent from the northern outfall pipe; the concentration was reported to be 0.23 mg/l. Massachusetts does not currently have a surface water quality standard for MBAS. The US Environmental Protection Agency's National Secondary Drinking Water Regulations, non-enforceable guidelines for drinking water aesthetics, recommend 0.5 mg/l as the MBAS limit. Thus, the MBAS concentration tested on March 19, 2003 does not exceed the federal drinking water guidelines.

5.03 WATERSHED NUTRIENT LOADING

Nutrient budgets for nitrogen and phosphorus for Jordan Pond were estimated, and a summary of the results is contained in Table 5-1 in the Phase 1 report. The total nitrogen load for Jordan Pond was estimated to be approximately 546 kg/yr, of which 92 percent is a result of watershed loading. Approximately two-thirds of the nitrogen loading from the watershed is a result of residential land uses, which corresponds to 60 percent of the total nitrogen loading to the Pond. The total load for phosphorus for Jordan Pond was estimated to be approximately 108 kg/yr, of which watershed sources account for 90. Residential properties contribute 80 percent of the watershed loading, or 72 percent of the total load.

Nutrient loading from residential properties occurs in multiple forms, primarily through pet wastes (both on the street and in the yard) and fertilizers applied to lawns and gardens. Residential nutrient loading is greatly increased by the presence of on-site septic systems. Improperly functioning septic systems may be particular culprits, though these have been largely repaired in the Jordan Pond watershed. Residential, non-point source nutrient loading reductions must primarily be achieved through behavioral modifications by watershed residents. Waste generated by waterfowl and dogs is a significant contributor of bacteria and waterborne pathogens to Jordan Pond. To attempt to meet the state health code for contact recreation for bacteria, it would be necessary to take steps to reduce the impact of waterfowl and to encourage watershed residents to clean up after their pets.

5.04 NPDES PHASE II STORMWATER PROGRAM

In 1990, the EPA began a stormwater management program called the National Pollutant Discharge Elimination System (NPDES), aimed primarily at municipal separate storm sewer systems (MS4s) serving greater than 100,000 people. The NPDES Phase II Final Rule, which was published in 1999 and became effective in March, 2003, expanded the scope of the NPDES program to include, among others, MS4s serving "small communities and urbanized areas;" 251 communities in Massachusetts, including the Town of Shrewsbury, fall under the regulations of the NPDES Phase II program.

The goal of NPDES Phase II is to "reduce discharge of pollutants to the maximum extent practicable" through the development and implementation of a stormwater management plan addressing six minimum control measures:

1. Public education and outreach
2. Public involvement/ participation
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post-construction runoff control
6. Pollution prevention/ good housekeeping for municipal operators.

The installation of in-line stormwater treatment systems and implementation of the alternative watershed management techniques presented here and in the Jordan Pond Restoration Project Phase 1 report may serve to fulfill many of the NPDES Phase II requirements for the Town of Shrewsbury.

6.00 IN-LINE STORMWATER WATER QUALITY TREATMENT

6.01 CONCEPT

GZA recommends that in-line stormwater treatment systems, in the form of modified manholes, be installed at selected locations within the Jordan Pond watershed. Manholes modified with in-line hydrodynamic separator devices are a method of upstream stormwater treatment within the existing stormdrain lines. The systems are similar to conventional manholes, but act as pollution prevention devices that are designed to remove 60 to 80 percent of total suspended solids and 70 to 100 percent of floatable oil and grease from the stormwater. In addition to removing solids, such devices also remove nutrients or other contaminants which are sorbed to particulate matter which settles within the device. The manholes typically consist of three sections: a separation/ storage chamber at the bottom; a bypass chamber above; and a central maintenance shaft that rises through the first two sections to street level. They are designed to be installed like a conventional manhole, and replaces oil-grit separators, sand filters, and other more complex in-line devices. These devices are also intended to trap fuel oil and hazardous materials in the event of an accidental spill. The designs have been extensively tested and approved by the U.S. Environmental Protection Agency and MADEP, and have been installed in many locations throughout New England and the rest of the country. Typical units cost approximately $5,000 to $65,000, depending on size and excluding design and installation. In-line stormwater treatment devices require a similar maintenance and clean-out program as catch basins.

6.02 EFFECTIVENESS

The effectiveness of in-line stormwater treatment devices greatly depends on a number of site-specific parameters, including:

- Sediment particle size distribution. This is especially important, as size of soil particles controls their settling velocity, and settling is the primary means of sediment removal provided by the devices.
- The fraction of dissolved phosphorus versus total phosphorus. Stormwater treatment devices are not effective at removing dissolved phosphorus (or any other dissolved contaminates); however, they have been shown to be effective at removing phosphorus which is sorbed to sediment or other particulate matter.
- The intensity and duration of the storm event.

In-line stormwater treatment devices have been installed in tens of thousands of locations across the United States and internationally, and water quality data has been collected at numerous sites for numerous storm events. In general, when properly sized and maintained, the devices are said to reliably remove over 80 percent of Total Suspended Solids, down to a particle size of 20 micrometers (silt-sized particles). Also, testing has shown that the devices can achieve up to a 97 percent removal efficiency of oils, grease, and other floatables. Many of the systems are designed such that high-flow events can be bypassed without treatment, thus preventing scouring, re-suspension, damage to the unit, or upstream flooding. An added benefit of installing these devices is their potential to contain or mitigate the damage resulting from gasoline and oil spills, by trapping the spilled material within the chamber.

6.03 DEVICES AND SYSTEMS

The following text is excerpted from a U.S. EPA fact sheet regarding hydrodynamic separators, which is another name for the type of in-line stormwater quality treatment devices discussed in this report.

"[In-line stormwater treatment devices] are flow-through structures with a settling or separation unit to remove sediments and other pollutants that are widely used in storm water treatment. No outside power source is required, because the energy of the flowing water allows the sediments to efficiently separate. Depending on the type of unit, this separation may be by means of swirl action or indirect filtration. . .Variations of this unit have been designed to meet specific needs.

"[The treatment devices] are most effective where the materials to be removed from runoff are heavy particulates - which can be settled - or floatables - which can be captured, rather than solids with poor settleability or dissolved pollutants. In addition to the standard units, some vendors offer supplemental features to reduce the velocity of the flow entering the system. This increases the efficiency of the unit by allowing more sediments to settle out."

Appendix D contains further information about in-line stormwater treatment devices, including: (1) contact information for selected manufacturers; (2) a U.S. EPA fact sheet regarding hydrodynamic separators (a.k.a. stormwater treatment devices); and (3) device sizing tables provided by some major manufacturers.

7.00 ALTERNATIVE MANAGEMENT STRATEGIES

It is neither feasible nor cost-effective to install in-line stormwater treatment devices to treat all of the runoff entering Jordan Pond. Instead, GZA has identified six sub-basins where the installation of such devices would improve the quality of water entering the Pond. In **Figure 3-2**, we have identified these six sub-basins, but have also identified other areas within the watershed where alternative management strategies would be appropriate means of achieving some point-source and non-point source pollution control. These alternative strategies are discussed below.

Preserve Open Space

Remaining open space within urbanized areas in the northeastern United States is a valuable commodity. The Jordan Pond watershed contains approximately 30 percent forested or otherwise open, undeveloped land, which is both publicly and privately owned. As discussed in the Phase 1 report, to the extent possible, it is important for the Town to work to preserve this remaining open space from development, either through zoning or land acquisition.

Fertilizer Management Plan

Runoff from the school athletic fields located along the southwest bank of Jordan Pond is a likely source of nutrients to the Pond. GZA recommends that a fertilizer management plan be developed for the field complex. This plan should seek to minimize fertilizer usage, to consider the application of low phosphorus or phosphorus-free fertilizer, and to provide guidelines as to the application schedule, rates, and methods by which to minimize the runoff of nutrient-rich fertilizer to Jordan Pond.

Implement Non-Structural and Inlet Best Management Practices (BMPs)

There are a number of low-cost watershed management options which can be implemented on a local and watershed-wide basis which, when aggregated, can have a long-term, positive impact on the water quality within Jordan Pond. A number of these options were discussed in the Phase 1 report. In the developed potions of the Jordan Pond watershed where stormwater quality is not addressed by the installation of in-line stormwater treatment devices, GZA recommends the Town implement some, if not all, of the following BMPs over the entire watershed:

- <u>Semi-annual (i.e.: twice a year) or annual catch basin cleaning</u>. This activity involves the removal of sediment, debris, and trash which accumulates in catch basin sumps so as to prevent it from washing downstream into the Pond. Typically, these efforts are conducted in the summer. In many cases, during a winter thaw or with the onset of an early spring, these activities should be conducted significantly earlier. It is critical to remove the accumulated sediment from the winter months as soon as possible before heavy and frequent spring precipitation, especially for catch basins without deep sumps or basins that have not been maintained in years.

- <u>Semi-annual or more frequent street sweeping</u>. One effective nonstructural source control is street (and parking lot) sweeping. Typically, these street sweeping efforts generally are conducted once a month during the late spring, summer, and early fall seasons. These street sweeping programs provide important non-point source pollution control. The period immediately following winter snowmelt, when road sand and other accumulated sediment may be washed off, is a particularly important time to do street sweeping. The ability of street sweeping efforts to remove pollutants which accumulate on road and parking lot surfaces varies according to frequency, type of sweeping equipment, and the amount of pollutants present. According to MADEP and based on data collected from different areas of the country, total suspended solids (TSS) removal for street sweeping practices range from negligible (<5%) to moderately effective (50-80%). Data indicate that infrequent sweepings (less than 20 times per year) with conventional mechanical sweepers results in average TSS removal efficiencies no greater than 20%. Newer vacuum type sweepers have demonstrated higher removal efficiencies.

- Catch basin stencils indicating that the sewers drain to Jordan Pond: Awareness by the public may discourage disposal of toxic or other undesirable substances into the stormdrain system.

- Utilize best management practices for snow removal and road sanding: Over-sanding and over-salting of the roads within the watershed should be discouraged so long as roadway safety is not compromised. Snow disposal areas should be located at sites where runoff does not directly enter wetlands or waterbodies and ideally where gradual infiltration of meltwater is possible. MADEP has developed guidelines for snow disposal which are available on the internet at http://www.state.ma.us/dep/brp/files/snowdisp.htm

- Installation of water quality hoods in catch basins: Outlet hoods may be retrofit into existing stormwater manholes and catch basins. These hoods fit over the outlet pipe in a sumped catch basin and minimizes the passage of oils, trash, and other floatables by trapping them in the basin. One type of hood is called the "Snout™", which is a proprietary device consisting of simple fiberglass hoods and air vent. Snouts™ are available in 12 to 30-inch diameters, and cost approximately $250 to $450 each, excluding installation. The snouts are designed to be simple and quick to install in existing catch basins. Contact information for the manufacture of the Snout is provided in **Appendix D**. A sample drawing is contained in **Appendix E**. Other similar hoods made of other materials and/or by other manufacturers are available.

Vacuum Truck Purchase

Another option which that Town may wish to pursue is the purchase of a vacuum truck. Owning such a truck, as opposed to contracting the services of an outside vendor, may allow the Town to realize a long-term cost-savings from their expected catch basin and in-line stormwater treatment system clean-out costs. The capital cost of a vacuum truck ranges from $100,000 to $200,000; excluding maintenance and other associated costs. GZA recommends that the Town perform a cost-benefit analysis to determine the merit of such a purchase, as compared to contracting for on-going services.

8.00 PRELIMINARY DEVICE SIZING AND LOCATIONS

GZA has selected six sub-basins where in-line stormwater quality treatment devices might be placed in order to assist with improving the quality of runoff entering Jordan Pond. These sub-basins are presented in Section 3.03.

8.01 DESIGN RATIONALES

The six sub-basins identified for treatment device installation were chosen based on the following selection criteria:

- Areas of high benefit to cost ratio; i.e.: areas likely to have significant pollutant loading which may be substantially minimized by the installation of an in-line treatment device.
- Areas where stormwater is drained by a feeder line which is designed to carry a small enough quantity of flow such that a substantial portion of the flow (over 80 percent) can be treated by an in-line device. The locations of such feeder lines were identified from the limited stormwater drainage plan provided to GZA by the Town.
- Areas likely to contribute pollutants of special concern to water and sediment quality in Jordan Pond, such as nutrients, sediment (sand), metals, pathogens, and TPH.
- Residential areas in close proximity to Jordan Pond which meet the above criteria. The residential areas identified for treatment device installation do not necessarily contribute any greater or lesser stormwater pollutant loadings than any other residential area within the watershed; however, their close proximity to the Pond means that these is less opportunity for decay and other removal processes to occur before the stormwater enters the Pond.
- Areas with a large percentage of impervious surfaces, where the majority of precipitation enters Jordan Pond as stormwater through the drainage network. Impervious surfaces prevent the infiltration of water into the ground, and the subsequent filtration by the subsurface strata prior to discharge into Jordan Pond as baseflow.

8.02 DEP STORMWATER MANAGEMENT STANDARDS

GZA additionally utilized the policies contained in the Massachusetts Department of Environmental Protection's *Stormwater Management Volume One: Stormwater Policy Handbook* (March 1997). This statewide policy presents nine stormwater management standards which are applicable to industrial, commercial, institutional, residential subdivision and roadway projects, including site preparation, construction, redevelopment, and on-going operation. These standards apply to municipal storm sewers under the regulations supporting the state Clean Waters Act; although they are typically not aggressively applied to existing systems. The Handbook states that "Existing stormwater discharges will be evaluated by DEP under its Clean Waters Act Authority on a case-by-case basis within a watershed authority." The Handbook further clarifies the jurisdiction of the state DEP over discharges from existing development by stating, "Existing discharges include municipal storm sewer systems, road and highway drainage systems, and drainage structures from developed areas with point sources to wetlands or water bodies." However, DEP typically will only actively seek to apply the standards to existing municipal stormwater systems when specific stormwater discharge is determined to be a priority problem within a watershed.

The nine DEP-mandated stormwater management standards are summarized as follows:

1. No new stormwater outfalls may discharge untreated stormwater or cause erosion.
2. Post-development peak discharge rates must not exceed pre-development discharge rates.
3. Annual recharge (groundwater infiltration) must not be significantly altered, based on soil types.
4. For new developments, stormwater management systems must be designed to remove 80 percent of the average annual load of Total Suspended Solids (TSS).
5. Stormwater discharges from areas with higher pollution potential must be specially treated and infiltration without pre-treatment is prohibited.
6. Stormwater discharge to critical areas must utilize specific stormwater management Best Management Practices (BMPs).
7. Redevelopment projects must meet the Stormwater Management Standards to the maximum extent practicable. This is defined as making all reasonable efforts to meet the standards, including evaluation of alternative BMP designs and their locations. If all standards cannot be met, retrofitted stormwater management systems must be designed to improve existing conditions.
8. Erosion and sediment controls must be used during construction activities.
9. All stormwater management systems must have an operation and maintenance plan.

8.03 SIZING AND LOCATIONS

In general, the retrofit of storm sewers would likely be required to comply only with the last three standards (Nos. 7, 8, & 9). Stormwater treatment would need to be provided "to the maximum extent practicable," erosion control would be required during the actual construction or installation of any devices, and an operations and maintenance plan would be required. However, even though the other standards are not likely to be directly applicable, they provide useful guidance for preliminary design of the in-line treatment devices. The desired total volume of stormwater runoff to be treated during a single precipitation event (as shown in **Table 8-1**) was estimated based on the DEP guidelines which indicate that for discharges into non-critical areas, the volume to be treated is calculated as 0.5 inches of runoff times the total impervious area of the post-development project site (i.e. sub-basin).

Sub-Basin	Area (acres)	% Impervious	Impervious Area (acres)	Volume of runoff to be treated (ft^3)*
A	9.8	90	8.8	16,000
B	7.3	50	3.7	6,600
C	3.3	90	3.0	5,400
D	1.6	98	1.6	2,900
E	1.5	100	1.5	2,700
F	4.6	50	2.3	4,200

Table 8-1. Stormwater treatment system sizing criteria.

*Based on 0.5 inches x (impervious area)

In conformance with the goals set forth in Standard No. 4, the systems were sized to achieve a minimum Total Suspended Solids (TSS) removal efficiency of 80 percent. GZA utilized software provided by the Stormceptor for use in sizing its units given specific sub-basin parameters such as size of the drainage area and percent of impervious cover. While the Sizing Tool software utilized is specific to the Stormceptor units, the general principals apply to all of the four proprietary devices described in Appendix D. Therefore, it is expected that similar sizes would be appropriate if products from other vendors are utilized. In all cases, the final sizing of the each in-line stormwater treatment unit should be verified by the manufacturer based on the performance standard of minimum TSS removal of 80 percent and ability to treat runoff volumes as cited in Table 8-1. Final sizing may then be compared against the unit characteristics shown in **Table 8-2** below. It should be noted that the size of the device for sub-basin E, which drains Route 9, has been increased beyond what would typically be required. This was done to accommodate expected high volumes of sand and to decrease the necessary frequency of maintenance.

Sub-Basin	Storm*ceptor* Model (or equivalent)	% TSS Removal	% Runoff Treated
A	16000*s*	82	87
B	7200	83	88
C	2400	83	85
D	2400	84	86
E	3600	85	87
F	3600	80	80

Table 8-2. Stormwater treatment system removal and treatment efficiencies.

The sub-basins previously identified in this report have been selected as the most appropriate locations for in-line treatment devices within the Jordan Pond watershed, in GZA's opinion. The precise location within each sub-basin is left to final design, but approximate locations are indicated on Figure 3-2. The in-line stormwater treatment systems should be located on the stormwater feeder lines immediately prior to the confluence with a trunk line, in order to treat the greatest percentage of flow emanating from each of the sub-basins. A detailed stormwater drainage network plan, including the pipe invert elevations and surface grades, is necessary to precisely site the device installation locations and verify the suitability of particular size devices for installation at a particular site.

There are no known current or pending regulatory actions which require existing commercial, industrial, or multi-family housing developments in the area to implement stormwater management activities on-site. As such, any stormwater treatment or watershed management actions which the Town chooses to pursue at these types of facilities would likely have to be implemented in the public right-of-way. Alternatively, the Town could seek to develop partnerships with the owners of these facilities and developments to work together to improve stormwater runoff quality within the Jordan

Pond watershed. The involvement of private organizations and companies in watershed management activities may be viewed as proactive environmental responsibility and a "good neighbor" action. The installation of such facilities on private property might also be a part of required mitigations during future re-development or expansion of the facilities on these sites.

9.00 PRELIMINARY DEVICE PRIORITIZATION AND COST

Based on sub-basin land use and other factors, GZA has prioritized the proposed stormwater treatment device locations according to our judgment regarding potential overall water quality improvements. GZA has also provided preliminary cost estimates for the purchase and installation of the devices.

The estimated costs provided below in **Table 9-1** are for Stormceptor model size sufficient to meet the design treatment and flow requirements for each sub-basin; costs for devices furnished by other vendors are similar to those shown.

Sub-Basin	Storm*ceptor* Model (or equivalent)	Estimated Unit Cost (2003 $)	Estimated Installation Costs (2003 $)*	Estimated Total Cost (2003 $)	Priority
A	16000*s*	$65,000	$40,000	$105,000	High
B	7200	$35,000	$20,000	$55,000	Low
C	2400	$15,000	$12,500	$27,500	Medium
D	2400	$15,000	$12,500	$27,500	Medium
E	3600	$17,200	$12,800	$30,000	High
F	3600	$17,200	$12,800	$30,000	Low

Table 9-1. Stormwater treatment system estimated cost and priority.

*Estimated installation costs include delivery, excavation, installation, traffic control, and backfill (but not design), and is estimated based on GZA's past project experience.

It should be noted that the estimated installation costs assume that the invert elevations and alignments of the existing stormwater drainage pipes are appropriate for the installation of an in-line stormwater treatment device of the recommended size. It has also been assumed that excavation and foundation conditions are typical (i.e. no bedrock excavation or utilities relocation is required). These conditions must be verified prior to final design. Unexpected subsurface conditions may lead to increased costs.

In GZA's opinion, the installation of stormwater treatment devices in sub-basins A and E is likely to result in the greatest improvement in stormwater quality entering Jordan Pond when considered relative to the costs, as these sub-basins are likely a significant source of nutrients, pathogens, sediment, metals, hydrocarbons, salt, and organics. **Table 9-2** summarizes the total estimated installed cost of the systems in each priority level and the overall estimated installed costs of all recommended systems.

System Priority Level	Sub-basins	Total Estimated Installed Cost (2003 $)
High	A, E	$135,000
Medium	C, D	$55,000
Low	B, F	$85,000
Total watershed cost:		**$275,000**

Table 9-2. Estimated total cost of Stormwater treatment system for each priority level.

Note that any watershed management options implemented at Jordan Pond will only improve the quality of water entering the Pond and will not have any impact on the quality of the sediments already in the Pond. Thus, when considered over a short time period, the installation of stormwater treatment devices in the Jordan Pond watershed are not likely to result in dramatic aesthetic or quantitative improvements in the quality of water within the Pond. Reduction of the sediment and pollutant loading into the Pond will, however, slow the progress of further degradation of the Pond and aid in the implementation of other management options.

10.00 GENERIC DETAILS AND SPECIFICATIONS

Sample detail design drawings and generic performance-based construction specifications are included as **Appendix E** and **Appendix F**, respectively. These materials are intended to be used only as a conceptual-level guide; construction and installation activities require job-specific plans and specifications and the services of a Professional Engineer licensed in the Commonwealth of Massachusetts.

Additional information required in project-specific specifications includes:

- Inlet and outlet pipe sizes and types;
- Specifications related to the exact unit model to be installed;
- Invert elevations;
- Local permits and regulations; and
- Traffic control and traffic safety plans.

11.00 OPERATION AND MAINTENANCE GUIDELINES

Regular inspections and proper maintenance are crucial to the effective operation of any in-line stormwater treatment device. These units are designed so that stormwater flow may pass through the unit; large volumes of accumulated sediment reduce the useable treatment capacity of the devices and can result in decreased treatment performance. Also, small debris, such as soda cans, tree branches, and Styrofoam cups may become trapped within the flow openings in the unit, potentially reducing the effective opening size and restricting the flow-through capacity of the units. The problem is exacerbated during intense storm events, as these blockages may cause water to backup in the drainage system and may potentially increase the risk of upstream flooding.

Most manufacturers recommend frequent inspections of the unit within the first year of installation, typically on one month to three month intervals; these frequent inspections are to establish the rate of sediment, oil and grease, and other floatables accumulation. All of the units are designed to be inspected and generally maintained from the ground surface, minimizing or eliminating the need for confined space entry. A sediment probe, such as the Sludge Judge brand, can be used from the ground surface to estimate the sediment depth within the unit. Some stormwater treatment devices are designed to allow entry into the chamber for thorough clean-out and inspections, sewer camera surveys, or sewer line flushing. Based on the findings of the first year of frequent inspections pertaining to material accumulation within the devices, a maintenance schedule can be established for regular inspection and clean-out.

Each manufacturer provides guidelines and information regarding when the unit is considered "full" of sediment, oils, or other debris, and thus when the unit should be cleaned out. Depending on the quality of the stormwater runoff and site-specific conditions, most units typically require clean-out every six months to two years. The units are cleaned-out via a standard vacuum truck, such as would be used for scheduled catch basin cleaning. The material removed from the devices should be handled and disposed of in accordance with all local, state and federal regulations pertaining to contaminated solid waste; typically, the material is not regulated as hazardous material, and may be transported to a sanitary landfill. A sample stormwater treatment system inspection and maintenance log form is attached as **Appendix G.**

12.00 RECOMMENDATIONS AND CONCLUSIONS

Jordan Pond has a long history of water quality impairments. Phase 1 of the Jordan Pond Restoration Study identified and quantified the impairments within the Pond, as well as the impacts of Pond sediment and watershed loading on overall water quality within the Pond.

As discussed in the Phase 1 report, only a large-scale in-pond management program which addresses the problem of the Pond sediment will truly come close to "solving" Jordan Pond's water quality issues. However, such an activity would be costly, complex, and certainly not without drawbacks, including major potential environmental impacts. In lieu of such an in-pond management activity, there are a number of smaller in-pond and watershed management techniques that can provide both measurable water quality improvements and improved aesthetics in Jordan Pond. The installation of in-line stormwater treatment systems within the Jordan Pond watershed is an example of a watershed management technique which has a proven track record of success and would be a feasible, effective technique in the case of Jordan Pond.

GZA recommends that the Town of Shrewsbury work to install in-line stormwater treatment devices in the sub-basins identified and prioritized in this report. As additional information regarding the Town's stormwater drainage network becomes available in the future, the Town may be able to identify additional sub-basins where in-line treatment system installation is feasible. GZA recommends that the Town implement some or all of the alternative watershed management options described here and in the Phase 1 report. Many of these options may be implemented at a very low cost, and can have a surprisingly positive impact on water quality. In addition, many of the watershed management techniques listed serve to fulfill the requirements set forth by the U.S. EPA under the NPDES Phase II Stormwater Program.

Installation of the recommended in-line stormwater treatment devices will require additional engineering work. Such work includes detailed field surveys to establish exact locations, sizes, and invert elevations of existing stormwater drainage system elements such as inlets, catch basins, and storm sewer pipes. Limited geotechnical explorations are also recommended to determine soil conditions and depth to bedrock at the proposed installation location. Detailed installation plans incorporating this data should then be developed during final engineering design. Permits may also be necessary for the installation of the devices. Permission from the Town is generally required prior to cutting pavement and installing utilities under a public right-of-way. The Conservation Commission should also be consulted regarding the proposed work. While none of the proposed treatment device locations are thought to be within wetlands resource areas or buffer zones, this must be confirmed. Additionally, the notification of the Conservation Commission and DEP through a Request for Determination of Applicability, at minimum, may be appropriate since changes to the storm water system ultimately impact on wetlands resources, albeit in a positive way under this proposed project. GZA is experienced with both the engineering and permitting procedures necessary for installation of the proposed in-line stormwater treatment devices. We would be pleased to provided the Town and/or the Watershed Association with these services and/or with assistance in seeking funding for implementation through the preparation and submission of grant applications.

GZA recommends and fully supports the concept of installing in-line stormwater treatment systems and implementing other watershed controls in the Jordan Pond watershed. However, both the Town and other stakeholders should be aware that these measures are unlikely to lead to any immediate improvements in conditions at Jordan Pond. The sediments and nutrients which are already in the Pond will continue to cause excessive plant growth and algae blooms, in GZA's opinion. We believe that in-line stormwater treatment devices are an appropriate, relatively low-cost solution which, while not addressing the root causes of degradation in the Pond, may satisfactorily reduce additional sediment and nutrient loading to the Pond. Combined with non-structural watershed management practices and potentially with changes in landscaping around the pond and/or an in-pond chemical treatment program, it is believed that in-line stormwater treatment systems offer a feasible and achievable program to begin to address the problems identified at Jordan Pond and reclaim the resource for the Town and its citizens.